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Take my advice: Physiological measures reveal that intrinsic emotion regulation is more effective under external guidance

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ABSTRACT

Research into emotion regulation (ER) has focused primarily on the intra-personal process through which we regulate our own emotions intrinsically. More recently, however, studies have begun to explore the inter-personal nature of intrinsic ER – that is, how we regulate our emotions under the guidance of others. Preliminary evidence suggests that ER might be more effective when implemented in an inter- compared with an intra-personal manner, but these findings are based almost exclusively on self-reported ratings that capture only the subjective experience of emotions. The current study therefore investigated whether this apparent superiority of inter-personal intrinsic ER could be replicated and extended to physiological measures of affective reactions – namely, various metrics of electrodermal activity. In a within-subjects design, a sufficiently powered sample (N = 146) were required to down-regulate their emotional reactions to negatively valenced images using an ER strategy they had chosen themselves intra-personally or one that had been recommended to them inter-personally. Physiological responses converged to demonstrate the greater effectiveness of inter- over intra-personal ER in decreasing negative affective reactions, despite subjective ratings suggesting that participants perceived the opposite to be true. The superiority of inter- over intra-personal ER in physiological recordings was unrelated to individuals' perceptions of their ability to regulate their own emotions, however, and so it remains to be seen if and how such benefits extend to clinical populations.

1. Introduction

Emotion regulation (ER) describes the volitional process through which an emotional experience is altered (Gross, 2015; Tamir et al., 2020; Gross, 1998b). Since humans are inherently social, ER is influenced enormously by those around us (English et al., 2017; Dixon-Gordon et al., 2015); just as we support others in regulating their emotions, we often follow guidance provided from those around us when regulating our own affective states (Nozaki and Mikolajczak, 2020). This is referred to as extrinsic and intrinsic forms of inter-personal ER, respectively, and illustrates how the regulation of emotions often involves a complex interplay between affective and social processes (English et al., 2017; Butler, 2017). This differs from *intra*-personal ER – that is, when individuals regulate their own emotions without any external (social) support (Zaki and Williams, 2013). Although a wealth of research has informed our understanding of both intra- and inter-personal intrinsic ER, such as the regulatory strategies we tend to choose for ourselves in different situations (Gross, 2001; Bonanno and Burton, 2013; Sheppes and Meiran, 2007; Demaree et al., 2004) and how we implement those instructed or recommended to us by others (Zaki and Williams, 2013; Bernat et al., 2011; Jackson et al., 2000; Gross, 1998a), few studies have compared their effectiveness directly. Given the potential therapeutic implications of effective inter-personal intrinsic ER (e.g., patient-clinician interactions), the present study performed a psychophysiological assessment of its efficacy relative to intra-personal ER.

Inter-personal intrinsic ER is a goal-directed process, during which an individual interacts with one or more other people in an attempt to modify their own emotional state (Zaki, 2020; Zaki and Williams, 2013; Barthel et al., 2018). Preliminary findings from the few behavioral

Abbreviations: ER, emotion regulation; AmpSum, sum of amplitudes; nSCR, number of phasic skin conductance responses.

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studies that have compared this interactive process with intra-personal ER indicate that the former has the potential to be more effective at regulating emotions: Levy-Gigi and Shamay-Tsoory (2017), for example, found that individuals reported less intense negative emotions when they implemented an ER strategy recommended to them by their romantic partner compared to one that they had self-selected intra-personally. Morawetz et al. (2021) report the same reduction in subjective ratings of emotional intensity when individuals were guided by a close friend in down-regulating their negative affective reactions relative to when they attempted ER by themselves. Large-scale questionnaire data have also been used to demonstrate the enhanced effects of inter- relative to intra-personal intrinsic ER on self-reported psychological outcomes among female friends (Christensen et al., 2020). Although Morawetz et al. (2021) identified a brain system that appeared to differentiate between intra- and inter-personal intrinsic ER, direct comparisons of their effectiveness have relied exclusively on self-report ratings of emotional experience. Such subjective impressions are likely to reflect large individual differences in identifying and evaluating our emotional states accurately, and can be highly susceptible to expectation biases (Swart et al., 2009; Gross and Jazaieri, 2014; Sheppes et al., 2015). Although other studies have observed reductions in physiological indices of affective reactions within social settings (e.g., Lougheed et al., 2016; Uchino et al., 1999; Lepore et al., 1993), such objective metrics have not been used to compare intra- with inter-personal intrinsic ER.

Emotions are multifaceted constructs, comprising subjective experiences of valence and arousal, physiological responses (e.g., electrodermal activity) and behavioral (e.g., facial) expressions (Barrett and Bliss-Moreau, 2009). While some scholars assume these subsystems to be aligned at all times (Rosenberg, 1997; Ekman, 1992; Camodeca and Nava, 2020), research findings challenge this assumption in at least three ways (Hot et al., 2005; Gross, 1998a; Cacioppo and Tassinary, 1990; Brown et al., 2019). First, the intensity of an emotion has been shown to moderate the degree of convergence among these subsystems; subjective experiences correlate positively with both behavioral and physiological responses during high-intensity emotional states (Rosenberg and Ekman, 1994; Brown et al., 2019), but such convergence is reduced or abolished completely for low-intensity emotions (Sze et al., 2010; Mauss et al., 2005). Second, different ER strategies influence the degree of alignment; while some strategies (e.g., expressive suppression) appear to modify physiological indices but not subjective ratings (Gross, 1998a; Dan-Glauser and Gross, 2013; Gross and Levenson, 1993), others have the reverse effect (Urry, 2009; Ray et al., 2010). Third, the direction of regulation also influences convergence among affective subsystems. For example, Urry (2009) reports that unpleasant images were rated less negatively when individuals were asked to decrease their emotional reactions, despite no observable changes in their facial electromyograph, heart rate or skin conductance; but when asked to increase their negative emotions, both subjective ratings and physiological responses increased in parallel. Given this potential disconnect between subjective experiences and physiological measures of emotional state, the current study compared intra- and inter-personal intrinsic ER by assessing both self-report ratings and skin-conductance responses.

In the present study, we adapted an experimental paradigm used elsewhere (Levy-Gigi and Shamay-Tsoory, 2017; Sheppes et al., 2014; Sheppes et al., 2011) such that individuals implemented an ER strategy they had self-selected or one that had been recommended to them by an experimenter within an inter-personal setting. This paradigm combines the types of experimental procedure used frequently to assess directed intra-personal ER (e.g., Dan-Glauser and Gross, 2013; Goldin et al., 2008; Urry, 2009) with that employed commonly to assess individuals' preferences for ER strategies under different situations (e.g., Levy-Gigi et al., 2016; Scheibe et al., 2015; Sheppes et al., 2011). Our adaptation was based upon current knowledge of intra-personal ER: First, different mechanisms appear to underpin the up- and down-regulation of positive and negative emotions (Kim and Hamann, 2007). Since negative emotions are associated with greater physiological responses compared to positive or neutral emotions (Cacioppo and Gardner, 1999), and given the detrimental effects on one's mental and physical health from their chronic *dys*regulation (Aldao et al., 2010; Gross and Jazaieri, 2014; Barlow et al., 2004; Beaudreau and O'Hara, 2008; Cludius et al., 2020), the present study compared intra- and inter-personal intrinsic ER in terms of their effectiveness in reducing negative emotional reactions. Second, we focused our attention on two ER strategies that have received the majority of experimental attention to date: participants were free to choose between *reappraisal* – whereby the meaning conveyed by a stimulus is altered so as to modify the emotion(s) it evokes, or *disengagement* – a strategy that involves thinking of something unrelated to the present stimulus as a means of avoiding any emotion(s) it elicits (Goldin et al., 2008; Scheibe et al., 2015; Sheppes and Meiran, 2007; Hughes et al., 2020; McRae and Gross, 2020). Third, and perhaps most importantly, research has shown that people exhibit a preference for reappraisal when down-regulating their emotional reactions to low-arousal stimuli but choose disengagement for high-arousal images (Sheppes et al., 2014; Shafir and Sheppes, 2020). Furthermore, people report greater difficulties in implementing reappraisal in response to high-arousal stimuli (Hajcak et al., 2010), and evidence suggests a reduced efficacy of reappraisal under high and disengagement under low arousal (Shafir et al., 2015; Raio et al., 2013). To maximise the comparability of inter-personal intrinsic ER to the expected pattern of choices during its intra-personal counterpart, permitting a more direct comparison, individuals always received recommendations to disengage in response to high- and reappraise in response to low-arousal stimuli.

Goal-directed ER involves identifying the need to regulate, selecting an appropriate strategy, implementing the strategy and then evaluating its effectiveness (Gross, 2015). Here, we focus specifically on the latter two phases of ER. To evaluate the relative efficacy of intrinsic ER performed intra- or inter-personally, we moved away from the traditional control condition in which participants are instructed typically to "just look" at the images passively. Specifically, we compared subjective and physiological indices of negative emotional reactions under both types of ER against those acquired when participants viewed the emotion-eliciting images surrounded by a self-selected or externally directed coloured frame. Whilst not providing a true baseline, these frame trials allowed us to isolate the effect of implementing ER strategies under the intra- or inter-personal condition from those associated with decision-making processes or receiving external recommendations; the experimental and control trials were made equivalent except for the intrinsic ER element. Further, these frame trials allowed us to compare the effectiveness of self-selected or externally recommended top-down cognitive strategies (reappraisal and disengagement) against a more exogenous process; namely, the re-direction of attention away from the content of the emotion-eliciting stimulus and toward the coloured frame. Although such exogenous attentional (re-)allocation might serve as an ER strategy in its own right (e.g., MacLeod et al., 2002), this would occur earlier than the active cognitive control required for intrinsic ER; both are antecedent-focused strategies that serve to modulate emotional experiences before they are fully generated (Ochsner and Gross, 2005), but attentional shifts occur much earlier in the emotion generative process. As such, this offered a control condition against which the endogenous ER strategies implemented under the intra- and inter-personal conditions could be compared.

In light of the literature reviewed above, we hypothesised that negative emotions evoked by unpleasant stimuli would be more intense during intra- compared with inter-personal intrinsic ER, as indexed by higher subjective ratings and greater skin-conductance responses. Furthermore, given that previous studies have demonstrated the malleability of ER effectiveness according to self-efficacy (e.g., Colombo et al., 2020), we predicted that this superiority of inter- over intra-personal ER would be stronger for individuals with lower expectations about their capacity for intra-personal ER. Finally, we hypothesised that lower ratings and electrodermal responses would be observed under both intra- and inter-personal conditions during endogenous ER compared with trials in which participants passively viewed emotion-eliciting images surrounded by coloured frames.

2. Methods

All experimental scripts and materials are publicly available at https://osf.io/stcr4.

2.1. Participants

A power analysis performed in G-Power (Faul et al., 2007) for a repeated-measures 2 (Condition: Intra-personal, Inter-personal) x 3 (Strategy: Reappraisal, Disengagement, Frames) ANOVA (Cohen's f = 0.14, $\beta = 0.95$) indicated that a sample of 134 participants was required. To account for potential data loss, 153 students and staff were recruited from Aston University. All participants were fluent in English and their comprehension of the instructions written in English was confirmed during the practice trials that were completed prior to commencing the experiment, as detailed in the sections below. Data from seven of these individuals were omitted from any analyses due to technical issues that resulted in missing or interrupted physiological recordings, leaving a final sample of 146 participants (27 males; $M_{age} = 24.32$ [$SD_{age} = 7.88$; range = 18–63] years). The procedure was approved by the Research Ethics Committee of Aston University (ref: #1465) in accordance to the 1964 Declaration of Helsinki, and all participants gave their written informed consent prior to commencing the experiment. Upon completion, students were recompensed with course credits and staff with £10.

2.2. Procedure

The full experimental procedure comprised one short experimental task to assess participants' mood, three questionnaires measuring different personality characteristics, and the Emotion Regulation Task. In the sections below, however, we only describe and analyse data from measures that allowed us to evaluate the hypotheses presented above; all other measures are described and analysed in the accompanying Supplementary Materials. The entire protocol was administered with PsychoPy v1.90.1. (Peirce et al., 2019). Participants completed the procedure in a single session, in a shielded laboratory with an average temperature of 25 °C (SE = 0.11) measured across sessions (participants). Once the recording equipment had been placed onto participants (see below; *2.4. Physiological Data Acquisition*), they first performed the assessment of their mood and then completed the three questionnaires. Physiological recordings commenced during this time (but were not evaluated) to allow the electrodes to calibrate for a minimum of 10 min. Participants then practiced implementing disengagement and reappraisal ER with the experimenter before starting the Emotion Regulation Task.

2.3. Emotion regulation task

To assess participants' ability to regulate their emotions, we adapted an experimental procedure that has been validated elsewhere (Levy-Gigi and Shamay-Tsoory, 2017; Sheppes et al., 2014; Sheppes et al., 2011). This Emotion Regulation Task was performed in a within-subjects design; all participants viewed negatively valenced images under both an Intra- and Inter-personal condition, which were blocked and presented in a counterbalanced order to avoid any order effects. During the Intra-personal block, participants were asked to choose either one of two strategies to down-regulate their emotional response to the image (disengagement or reappraisal; $Intra_{ER}$) or a coloured frame to be presented around it (blue or green; $Intra_{Frame}$). In the Inter-personal condition, participants were instructed to implement the strategy or view the image surrounded by a frame colour chosen ostensibly by the experimenter ($Inter_{ER}$ or $Inter_{Frame}$, respectively; see Fig. 1 for an illustration of the protocol, and Supplementary Materials for full instructions given to participants).

All trials begin with a 1000 msec fixation cross that was followed immediately by a 500 msec preview of a negative image with either high or low normative arousal ratings (see below). This brief preview allowed participants and, ostensibly, the experimenter to decide upon the most effective ER strategy to implement or recommend (Sheppes et al., 2011). Participants were then given 5000 msec to make one of two choices, or prepare to implement a recommendation made to them: During the Intra-personal condition, they were required to choose between disengagement or reappraisal (left or right arrow key, respectively) as a strategy for down-regulating their emotional reaction to a subsequent 8000 msec presentation of that same image ($Intra_{ER}$ trials), or select either a blue or green frame to be presented around the image upon its subsequent presentation ('B' or 'G' key, respectively; $Intra_{Frame}$ trials). In the Inter-personal condition, they received an instruction on the ER strategy they should implement on the subsequent presentation of the image ($Inter_{ER}$; i.e. disengagement for high- and reappraisal for low-arousal trials), or they were told the frame colour they would see around the image ($Inter_{Frame}$). The experimenter sat with a laptop behind the participant throughout both conditions and participants were told that the recommendations presented to them during the Inter-personal condition were made by the experimenter. This positioning of the experimenter prevented any inadvertent social cues from confounding participants reactions to the stimuli. In the final 6000 msec trial segment, participants were asked to rate the intensity of their emotional response to the image on a 1 (low) to 9 (high) scale using the Self-Assessment Manikin (Bradley and Lang, 1994). These subjective ratings represent one of three dependent measures.

Before commencing the task, participants completed four trials to practice both ER strategies twice. Four images were used for these practice trials – two low- and two high-arousal. Each practice trial followed the same sequence illustrated in Fig. 1, but with an additional indefinite interval at the end for participants to verbalise their implementation of each strategy. Practice finished only if the experimenter was satisfied that the participant understood how to employ both regulation strategies. Following these practice trials, participants completed 120 experimental trials in total, split across an Intra- and Inter-personal block, each block consisting of 60 unique images – 30 low- and 30 high-arousal pictures, divided equally between $Intra_{ER}$/$Inter_{ER}$ and $Intra_{Frame}$/$Inter_{Frame}$ trials. The sequence of the two blocks was counterbalanced across participants.

The 124 images used across the practice and experimental trials were selected from the International Affective Picture System (IAPS; Lang et al., 2008). Following the requirements of the institutional review board, only images with normative valence ratings of 0–4 and arousal ratings of 3–5 were used; images with normative arousal ratings of 3.0–3.9 were classified as low arousal, and the remaining images were classed as high arousal.[1] Although different images were used in the Intra- and Inter-personal conditions, the two stimulus sets were matched closely on normative valence ($M_{Inter} = 3.93$, $SD_{Inter} = 0.80$; $M_{Intra} = 4.08$, $SD_{Intra} = 0.72$; $t_{[59]} = -1.02$, $p = .314$) and arousal ratings ($M_{Inter} = 4.01$, $SD_{Inter} = 0.57$; $M_{Intra} = 3.87$, $SD_{Intra} = 0.74$; $t_{[59]} = 1.25$, $p = .215$). The categorisation of these stimuli into high- and low-arousal was determined by mean normative arousal ratings (low = 3.39 [SD = 0.46], high = 4.49 [SD = 0.25]). In an event-related fashion, trials were presented in a pseudorandomised order such that neither ER nor Frame trials were presented successively on more than three occasions.

2.4. Self-efficacy in emotion regulation

Participants' self-estimation of their ER abilities was captured using the Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer,

[1] The images we label as 'high-arousal' might correspond more closely to the moderate-arousal images used in previous studies.

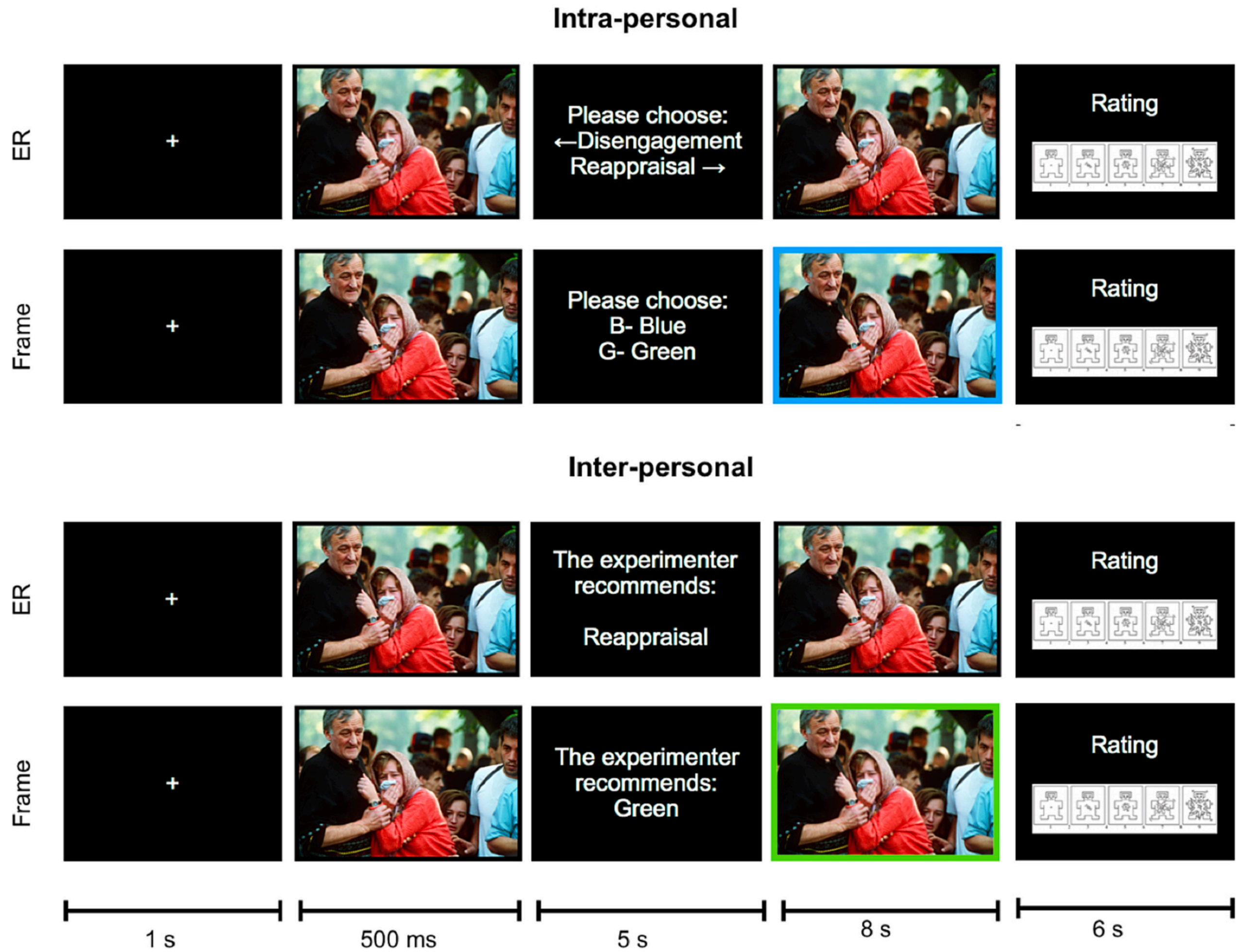

Fig. 1. Example trial sequences for the intra- and inter-personal condition.
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2004). This 36-item instrument includes the subscales "Awareness", "Clarity", "Goals", "Impulse", "Non-acceptance" and "Strategies". Participants respond to each item using a 5-point Likert scale, ranging from 1 ("Almost never") to 5 ("Almost always"). The DERS is used widely in research and clinical settings, and shows good construct validity and internal consistency for all subscales (Cronbach's α between 0.82 and 0.92; Hallion et al., 2018). In the current sample, the instrument achieved excellent reliability ($\alpha = 0.95$; mean = 88.93, SE = 2.40).

2.5. Physiological data acquisition

Electrodermal activity (EDA) was acquired with a Biopac MP36 system and Biopac Student Lab 4.0. Sampling was performed at 1 kHz, with a low-pass filter of 66.5 s, a quality factor of 0.5, and a gain of 2000. Two SS3LA transducers were treated with isotonic gel (Biopac Systems Inc.) and attached to the distal phalanges of participants' left middle and index finger. Triggers signalling trial and image onsets were sent from the Biopac computer to the stimulus PC via a STP35A parallel port cable.

2.6. Physiological data processing

The pre-processing and analysis of EDA data was performed using Ledalab (Benedek and Kaernbach, 2010), a toolbox for MATLAB R2017a (Mathworks, 2017). First, a constant was applied to ensure that the signal minimum was equal to 1. This signal was then downsampled to 50 Hz using a factor mean of 20, before being low-pass filtered with a first-order Butterworth filter (cut-off = 5 Hz) and smoothed with an adaptive filter that convolved the signal with a Gaussian window (σ = 200 ms). Once pre-processed, Continuous Decomposition Analysis was used to decompose skin conductance signals into tonic, slow-changing skin conductance levels and phasic skin conductance responses (SCRs). The skin conductance levels were identified as segments displaying increases of <0.01 μS using peak detection analyses, and were subsequently subtracted from the overall signal. Unlike traditional peak-and-trough detection approaches, SCR amplitude estimation with Continuous Decomposition Analysis does not require comparison to a "true" baseline (i.e. task-free sections of a continuous recording); rather, SCRs are identified by comparing peaks relative to the tonic skin conductance level (Benedek and Kaernbach, 2010). Participants' individual SCR shape was modelled using an impulse response function, which was estimated over four iterations to determine the best fit. The number of SCRs (nSCR) above 0.01 μS occurring 1–4 s following the onset of the 8 s image presentation, and the sum of their amplitudes (AmpSum) were used as two separate dependent measures of EDA.

3. Results

The means and standard errors of participants' subjective ratings, the number of skin-conductance responses (nSCRs) and the sum of their amplitudes (AmpSum) during each trial type are presented together in Table 1. Although the number of skin conductance responses (nSCR) were distributed normally, subjective ratings and the sum of amplitudes (AmpSum) were skewed positively. These measures were therefore corrected using square root and logarithmic transformations,

Table 1
Estimates (± standard error) of fixed and random effects for each dependent measure.

	Intercept (β_0)	Condition (β_1)	Strategy (β_{2j})		Arousal (β_{2j})	Condition x Strategy (β_3)		Condition x Arousal (β_3)
			Diseng.	Reappraisal		Diseng.	Reappraisal	
Ratings	0.50 (0.01)**	−0.001 (0.01)	–	–	−0.21 (0.01)**	–	–	0.06 (0.01)**
nSCR	1.41 (0.05)**	−0.06 (0.02)*	0.02 (0.02)	−0.001 (0.02)	–	–	–	–
AmpSum	0.27 (0.01)**	−0.05 (0.01)**	0.04 (0.01)**	0.03 (0.01)*	–	−0.03 (0.01)*	−0.04 (0.01)**	–

Note. The sign of estimates represents the difference relative to a reference category. The reference for the Condition effect was the Intra-personal condition; negative estimates signify lower dependent measures under the Inter- compared with the Intra-personal condition. The reference for the Arousal effect was the high category; negative estimates signify lower dependent measures low-arousal images. The reference for Strategy were the Frame trials; positive values signify greater dependent measures during reappraisal and/or disengagement.

* $p < .05$.

** $p < .001$.

respectively, prior to any analyses. Due to the imbalanced sex distribution, whole-group *and* females-only analyses were conducted; however, since the results of the latter did not differ significantly to those for the former, only whole-group findings are reported (a whole-group and females-only comparison is provided in Table S2 of the Supplementary Materials).

3.1. Distribution of strategy choices

Unlike the Inter-personal condition, in which recommendations to disengage or reappraise were fixed according to the arousal level of images, participants were free to choose between these strategies during the Intra-personal condition. For this reason, we first checked if the expected preference for ER strategies according to arousal level (i.e. appraisal for low- and disengagement for high-arousal images), which was fixed in the Inter-personal condition, was indeed reflected in the distribution of choices on Intra$_{ER}$ trials. To assess this, a 2 (Strategy: Disengagement, Reappraisal) x 2 (Arousal: Low, High) repeated-measures ANOVA was performed on the frequency of self-selections made under the Intra-personal condition. No significant main effects of Strategy ($F_{[1,\ 145]} = 3.76$, $p = .055$, $\eta^2_\rho = 0.03$) or Arousal were observed ($F_{[1,\ 145]} = 2.413$, $p = .122$, $\eta^2_\rho = 0.02$). Moreover, the Strategy-by-Arousal interaction was not significant ($F_{[1,\ 145]} = 1.331$, $p = .251$, $\eta^2_\rho = 0.01$). Thus, participants showed no systematic preference for a particular strategy under different levels of arousal (see Fig. 2); while some self-selected reappraisal most frequently in response to high-arousal images, others appeared to prefer disengagement for the same images.

3.2. Strategy effectiveness under self-selection or external recommendation

Given the imbalanced number of trials in which participants chose each strategy in response to low- and high-arousal images during the two conditions, it was inappropriate to compare their effectiveness with the planned 2 (Condition: Intra-personal, Inter-personal) x 3 (Strategy: Disengagement, Reappraisal, Frame) x 2 (Arousal: Low, High) repeated-measures ANOVA. Instead, we compared the effectiveness of intra- and inter-personal ER directly by first performing linear mixed models (LMMs); specifically, we compared the two conditions by considering only those trials that were equivalent – low-arousal trials in which reappraisal was self-selected or recommended, and high-arousal trials in which disengagement was self-selected or recommended.

A step-up approach was used to define the best-fitting model for each dependent measure: starting with a reference model containing only fixed main effects, we assessed improvements to model fit after intro-

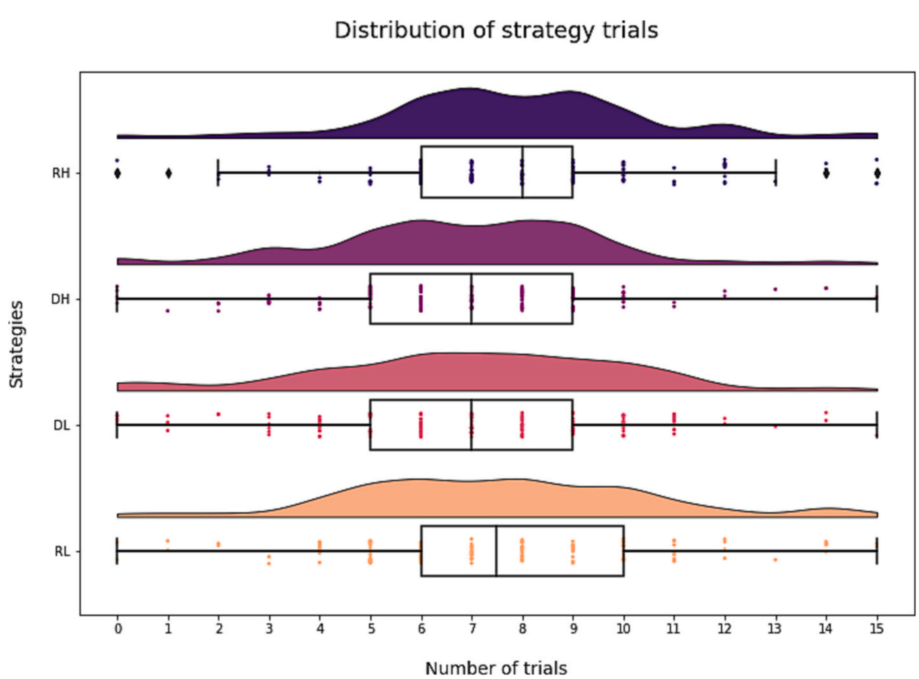

Fig. 2. Distribution of strategy choices during the Intra-personal condition across the entire sample. *Note*. Participants self-selected a strategy in response to 15 low- and 15 high-arousal images. DH and RH denote disengagement and reappraisal choices for high-arousal images, and DL and RL denote disengagement and reappraisal for low-arousal images, respectively.

ducing a random intercept, random main effects and fixed interactions sequentially (see Fig. S1 and Table S1 in the Supplementary Materials). In the Inter-personal condition, the effect of Strategy was confounded with Arousal; instructions to reappraise or disengage occurred only for low- and high-arousal images, respectively. Therefore, we compared two groups of models – the predictor for the first group was Strategy, whereas the second modelled Arousal as the predictor. Significant decreases in Akaike's Information Criteria (AIC; $p < .05$) were used to evaluate fit within each group of models, before comparing the best-fitting models of each group to one another. The following models achieved the best fit for each dependent measure, in which value *i* is estimated for each participant *j*:

(1)

$$\boldsymbol{Rating_{ij}} = \beta_{0j} + \beta_1(Condition) + \beta_{2j}(Arousal) + \beta_3(Condition\,x\,Arousal) + e_{ij}$$

(2)

$$\boldsymbol{nSCR_{ij}} = \beta_{0j} + \beta_1(Condition) + \beta_2(Strategy) + e_{ij}$$

(3)

$$\boldsymbol{AmpSum_{ij}} = \beta_{0j} + \beta_1(Condition) + \beta_{2j}(Strategy) + \beta_3(Condition\ x\ Strategy) + e_{ij}$$

Results from these LMMs are presented in Table 1. For Ratings, there was no significant main effect of Condition ($p = .832$), but a significant main effect of Arousal ($p < .001$) confirmed that low-arousal images elicited significantly weaker subjective emotional reactions compared with high-arousal images. Pairwise comparisons for the significant Condition-by-Arousal interaction ($p < .001$) revealed that, in response to low-arousal images, subjective emotional reactions were significantly less intense under the Intra- compared with the Inter-personal condition ($p < .001$), yet no such difference existed for high-arousal images ($p = .832$). For nSCRs, a significant main effect of Condition ($p = .001$) revealed a significantly higher frequency of physiological responses under the Intra- compared with the Inter-personal condition, but there was no significant main effect of Strategy ($p > .477$). Significant main effects of Condition ($p < .001$) and Strategy ($p < .001$) were observed for AmpSum, with significantly higher amplitudes of physiological responses being recorded during the Intra- relative to the Inter-personal condition ($p < .001$) and lower amplitudes for Frame trials relative to those in which disengagement ($p < .001$) and reappraisal was implemented ($p = .032$). No significant difference was observed between disengagement and reappraisal on ER trials ($p = .063$). Post-hoc assessments of the significant Condition-by-Strategy interaction ($p = .004$) revealed significantly higher AmpSum for Frame and ER trials in which disengagement and reappraisal was implemented during the Intra- compared with the Inter-personal condition ($p < .001$). During the Intra-personal condition, there was no significant difference between ER trials in which disengagement or reappraisal was self-selected ($p > .999$); however, amplitudes were significantly lower for Frame relative to both disengagement ($p < .001$) and reappraisal ER trials ($p < .001$). Within the Inter-personal condition, however, there were no significant differences between Disengagement and Reappraisal ($p = .056$) or Disengagement and Frame ($p = .277$) trials, and no significant difference between Reappraisal and Frame trials ($p = .876$).

In summary, both physiological responses supported our initial hypothesis by demonstrating decreased arousal following inter- compared with intra-personal ER. However, a contradictory pattern emerged for subjective responses. Furthermore, the physiological indices suggested improved ER during Frame trials relative to those in which effortful regulation was implemented using a strategy.

3.3. Direct comparison between all inter- vs. intra-personal ER trials

The LMM analyses accounted for the unequal numbers of strategy trials by comparing only those that were equivalent between the Inter- and Intra-personal condition; i.e. low-arousal reappraisal and high-arousal disengagement trials. To perform a direct comparison of the conditions that included all the available trials, we collapsed across the disengagement and reappraisal trials in order to perform a 2 (Condition: Intra-personal, Inter-personal) x 2 (Trial type: ER, Frame) x 2 (Arousal: Low, High) repeated-measures ANOVA. In the following section, Greenhouse–Geisser corrections have been applied where necessary. Data distributions are presented in Fig. 3.

For ratings (Fig. 3A), there were significant main effects of Condition ($F_{[1,\ 139]} = 21.01$, $p < .001$, $\eta^2_\rho = 0.13$), Trial type ($F_{[1,\ 139]} = 148.11$, $p < .001$, $\eta^2_\rho = 0.52$), and Arousal ($F_{[1,\ 139]} = 409.59$, $p < .001$, $\eta^2_\rho = 0.75$). Ratings were lower during the Intra- compared with the Inter-personal condition ($p < .001$), lower for ER compared with Frame trials ($p < .001$), and lower for low- compared with high-arousal trials ($p < .001$). This ANOVA also yielded a significant Condition-by-Trial type ($F_{[1,\ 139]} = 8.7$, $p = .004$, $\eta^2_\rho = 0.06$), Condition-by-Arousal ($F_{[1,\ 139]} = 16.0$, $p < .001$, $\eta^2_\rho = 0.1$), Trial Type-by-Arousal ($F_{[1,\ 139]} = 50.82$, $p < .001$, $\eta^2_\rho = 0.27$), and a three-way Condition-by-Trial type-by-Arousal interaction ($F_{[1,\ 139]} = 29.29$, $p < .001$, $\eta^2_\rho = 0.17$): $Intra_{ER}$ trials were rated significantly lower than $Inter_{ER}$ trials ($p = .019$), $Intra_{Frame}$ lower than $Inter_{Frame}$ trials ($p < .001$), $Intra_{ER}$ lower than $Intra_{Frame}$ trials ($p < .001$), and $Inter_{ER}$ lower than $Inter_{Frame}$ ($p < .001$). Lower ratings were also reported following low- relative to high-arousal trials within both the Intra- ($p < .001$) and Inter-personal conditions ($p < .001$). Further, low-arousal Intra-personal trials were rated lower than low-arousal Inter-personal trials ($p < .001$). Post-hoc comparisons of the significant Trial Type-by-Arousal interaction revealed significantly lower ratings for low relative to high ER ($p < .001$) and Frame trials ($p < .001$). Similarly, ER compared with Frame trials yielded significantly lower ratings under both low ($p = .003$), and high ($p < .001$) arousal. Post-hoc tests of the significant three-way interaction suggested significantly lower ratings for $Intra_{ER}$ relative to $Inter_{ER}$ only under high arousal ($p = .009$). In response to low-arousal images, lower ratings were reported for $Intra_{Frame}$ relative to $Inter_{Frame}$ ($p < .001$), and $Inter_{ER}$ relative to $Inter_{Frame}$ ($p < .001$). For high-arousal images, lower ratings were observed during $Intra_{ER}$ compared with $Intra_{Frame}$ ($p < .001$), and $Inter_{ER}$ compared with $Inter_{Frame}$ ($p < .001$). These results indicate that subjective ratings of emotional reactions to the images did not support our primary hypotheses; intra-personal ER was rated as more effective than inter-personal ER when disengagement and reappraisal were collapsed into ER trials.

Opposing patterns emerged for the EDA measures, however. Significant main effects of Condition ($F_{[1,\ 139]} = 43.95$, $p < .001$, $\eta^2_\rho = 0.24$), Trial type ($F_{[1,\ 139]} = 12.79$, $p < .001$, $\eta^2_\rho = 0.08$), and Arousal ($F_{[1,\ 139]} = 5.85$, $p = .02$, $\eta^2_\rho = 0.04$) were observed for AmpSum (Fig. 3C): *higher* amplitudes were observed for the Intra- relative to the Inter-personal condition ($p < .001$), for ER compared with Frame trials ($p < .001$), and, as with ratings, high- compared with low-arousal trials ($p = .017$). Further, there was a significant Condition-by-Trial type interaction ($F_{[1,\ 139]} = 7.26$, $p = .008$, $\eta^2_\rho = 0.05$); this revealed significantly *higher* AmpSum for $Intra_{ER}$ compared with $Inter_{ER}$ ($p < .001$), $Intra_{ER}$ compared with $Intra_{Frame}$ ($p < .001$), and $Intra_{Frame}$ compared with $Inter_{Frame}$ ($p < .001$). There was also a significant Trial type-by-Arousal interaction ($F_{[1,\ 139]} = 8.94$, $p = .003$, $\eta^2_\rho = 0.06$), which revealed significantly lower amplitudes elicited during low- compared with high-arousal ER trials ($p = .002$), and higher amplitudes for high-arousal ER relative to Frame trials ($p < .001$). For nSCRs (Fig. 3B), only a significant Trial type-by-Arousal interaction emerged ($F_{[1,\ 139]} = 8.04$, $p = .005$, $\eta^2_\rho = 0.06$); high-arousal ER trials elicited more nSCRs than high-arousal Frame

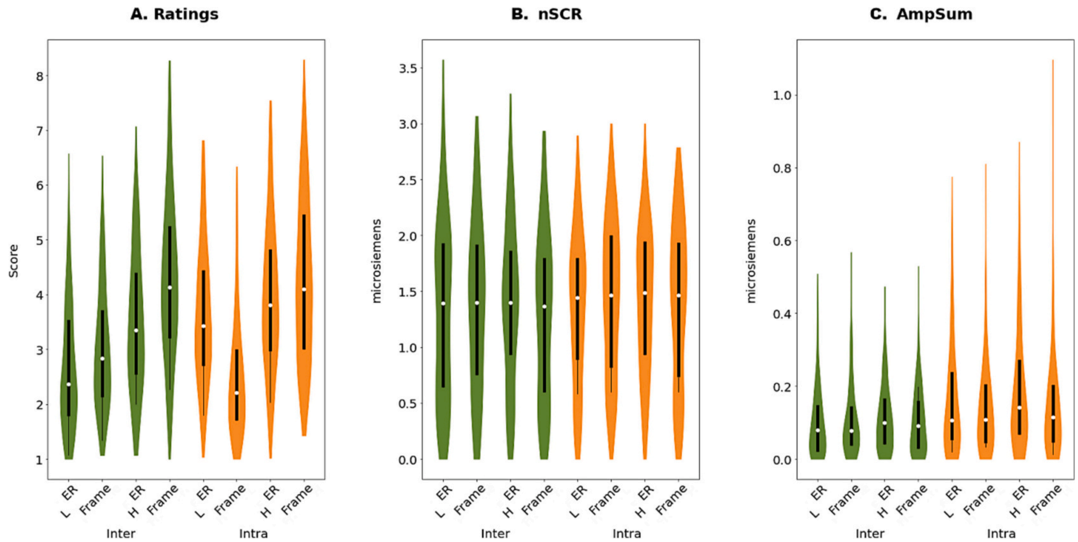

Fig. 3. Distributions of subjective ratings and electrodermal metrics across the Inter- and Intra-personal conditions under low- and high-arousal stimuli. *Note*: ER = emotion regulation, L = low arousal, H = high arousal; $N = 146$ after list-wise deletion.

trials ($p = .025$), and less nSCRs were observed for low- compared with high-arousal Frame trials ($p = .004$). In summary, our hypotheses were supported by physiological indices; amplitudes were reduced for inter- relative to intra-personal ER when all regulation trials were considered.

3.4. Relationship between self-efficacy and performance-based measurements of emotion regulation

To evaluate our hypothesis that ER would be more effective in the Inter- compared with the Intra-personal condition particularly for individuals with lower self-efficacy, we first created a single measure of relative effectiveness; specifically, for each of the dependent measures taken during the Emotion Regulation Task, we subtracted mean responses during Inter_{ER} from Intra_{ER}. Positive difference scores indicate the superior effectiveness of Inter_{ER} over Intra_{ER} (reduced affective responses in the former relative to the latter). Separate linear regression analyses were then used to assess if total DERS score predicted participants' difference scores for each of the dependent measures. This revealed that DERS scores did not significantly predict relative rating responses ($R^2 < 0.001$, $F_{[1, 137]} < 0.001$, $\beta = 0.001$, $p = .991$), nSCRs ($R^2 = 0.002$, $F_{[1, 137]} = 0.235$, $\beta = 0.042$, $p = .628$) or AmpSum ($R^2 = 0.002$, $F_{[1137]} = 0.299$, $\beta = 0.047$,$p = .585$).

4. Discussion

The present study performed a comparison of emotion regulation (ER) effectiveness when we are free to choose between two regulatory strategies without any prior external guidance (intra-personal) and under instruction from another person (inter-personal). To do so comprehensively, we assessed both subjective ratings and electrodermal activity (EDA) as indices of emotional reactions while a large sample of individuals down-regulated their negative emotional reactions intra- or inter-personally. Driven by prior research, we hypothesised that higher ratings and elevated EDA would be observed during intra- compared with inter-personal intrinsic ER. Contrary to our predictions, when focusing only on trials in which the same ER strategies were implemented in response to low- or high-arousal images under both conditions, our data show decreased subjective ratings under intra- compared with inter-personal ER, but only in response to low-arousal stimuli. The physiological indices showed a different pattern, however; in support of our hypothesis, both the number and amplitude of skin-conductance responses (SCRs) were significantly *higher* under intra- relative to inter-personal ER, demonstrating the superior effectiveness of the latter in down-regulating affective responses. When collapsing across strategies, ratings were again unexpectedly lower under intra- compared with inter-personal ER, but the amplitude of SCRs remained significantly lower when implementing ER strategies directed by the experimenter inter-personally compared to those self-selected intra-personally. Furthermore, differences in individuals' self-perceived ability to regulate their emotions were not predictive of the superiority of inter- relative to intra-personal ER.

4.1. Comparing inter- and intra-personal intrinsic emotion regulation

Previous studies on inter-personal ER have focused predominantly on the type of ER strategies we recommend to others extrinsically (Pacella and López-Pérez, 2018; Netzer et al., 2015; Pauw et al., 2019), or the strategies we choose to implement ourselves during inter-personal contexts (see Lindsey, 2020). The few studies that have compared directly the efficacy of intra- relative to inter-personal intrinsic ER report the beneficial effects of the latter over the former (Lougheed et al., 2016; Morawetz et al., 2021; Levy-Gigi and Shamay-Tsoory, 2017). These earlier findings are based exclusively on individuals' subjective experiences of their affective reactions, however, which reflect only those aspects of emotions that are accessible to introspective evaluation. Although we observed no difference in subjective ratings between the conditions when they were equivalent in terms of the strategies implemented and arousal level of the stimuli, physiological indices of affective reactions were consistently lower during inter- compared with intra-personal ER. This serves to extend these earlier findings by demonstrating the enhanced effectiveness of ER when directed by another individual in an interpersonal setting. When collapsing across the strategies implemented, however, although physiological metrics remained higher during intra- compared to inter-personal intrinsic ER, subjective ratings were *lower* during the former. We propose that this discrepancy between our observations and those reported elsewhere (Levy-Gigi and Shamay-Tsoory, 2017; Morawetz et al., 2021) reflect large differences in sample size and/or subtle variations in experimental paradigms. Furthermore, ER can be divided into an identification, selection and implementation phase; individuals first become aware of the need to regulate, select an ER strategy that they feel is most appropriate, and then implement the chosen strategy (Gross, 2015). The current study focused specifically on the entire implementation phase of inter-personal ER, whereas previous investigations completed some of the

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implementation for the participant by providing predetermined examples of how to use each strategy (e.g. "Imagine this is not real"; Morawetz et al., 2021, Xie et al., 2016, Hallam et al., 2014). Future research should explore whether the relative benefit of inter- over intra-personal intrinsic ER is restricted to specific stages of the regulatory process.

The task now is to identify the mechanisms through which inter-personal ER exerts this superiority, at least in physiological metrics of affective reactions. One study might offer a clue in this respect: Lougheed et al. (2016) suggest that reduced physiological indices of emotional distress in daughters coupled with their mothers reflects load sharing – that is, the inter-personal distribution of burden associated with a challenging situation. Perhaps, then, an implicit agreement about the perceived appropriateness of an ER strategy between the person recommending it and the one implementing it serves to reduce any uncertainty about its efficacy, thereby increasing its effectiveness. Interestingly, inter-personal intrinsic ER appears to be supported by brain systems implicated in self-referential processing and social cognition (Morawetz et al., 2021), perhaps revealing neurophysiological mechanisms through which such convergence in self- and other-selected strategies increases the effectiveness of ER. Future studies might investigate this further by comparing the effectiveness of inter-personal ER under different levels of agreement between the advisor and the target of their recommendations.

At this point it is important to stress that a fixed strategy of recommendations was followed during inter-personal ER in this laboratory-based experiment; participants always received an instruction to reappraise for low- and disengage for high-arousal images, ostensibly from the experimenter who was present in the room. Unlike previous studies (e.g., Shafir et al., 2015; Shafir and Sheppes, 2020; Sheppes et al., 2014), this schedule did not reflect self-selected choices during intra-personal ER in the current sample. This leads us to question whether the increased effectiveness of inter- over intra-personal ER that we have observed is due solely to this particular recommendation schedule or to the interpersonal dynamic itself. Preliminary data that we have acquired online using the exact same experimental task indicate that intra-personal ER continues to be rated *subjectively* as more effective than inter-personal ER even when different schedules of recommendations are made (e.g., reappraisal for high-arousal images; see Supplementary Materials). However, since these data were acquired online during the global pandemic and, therefore, without the physical presence of a recommending individual, further research is needed to determine whether or not the perceived superiority of intra- over inter-personal ER holds across different schedules recommended within a more naturalistic interpersonal (social) setting.

4.2. Associations among emotion subsystems

A key finding to emerge from this study was the discrepancy between self-report ratings and physiological responses. After accounting for the number of trials during which participants self-selected reappraisal for low- and disengagement for high-arousal stimuli, rating responses did not differ significantly during intra- and inter-personal ER. However, when collapsing across strategies, our results suggest greater self-perceived efficacy in decreasing negative emotions for intra- relative to inter-personal ER. Interestingly, inter- compared with intra-personal ER resulted in significantly, and consistently, *reduced* EDA responses. Similar disconnects between rating and EDA responses were observed when ER and Frame trials were compared: Frames were more effective in reducing physiological responses to negative images than endogenous ER strategies, particularly in response to high-arousal images, yet participants reported the opposite – lower ratings were given following the active use of an ER strategy compared with the passive viewing of images with coloured Frames.

Such discrepancies might reflect genuine differential effects of ER strategies on experiential and physiological indices of emotional reactions (Gross, 1998a). Few of the studies reporting convergence between subjective experiences and physiological responses have investigated the differential influence of specific ER strategies on this relationship, let alone strategies implemented within inter- and intra-personal settings (Robinson and Demaree, 2009; Dan-Glauser and Gross, 2013; Hubert and de Jong-Meyer, 1990; Driscoll et al., 2009). Two studies report that reappraisal reduces ratings to negative stimuli whilst having no influence on electrodermal activity (Urry, 2009; Urry, 2010). Specific ER strategies might therefore utilise different mechanisms to regulate emotions, which can modulate experiential and physiological systems independently. In this light, disconnects between intra- and inter-personal ER may reflect the different mechanisms through which they exert their regulatory influence.

Alternatively, disconnects between subjective and physiological measures might simply reflect methodological factors. For instance, we acquired physiological measurements *during* the implementation of ER strategies, whereas subjective ratings were acquired retrospectively after the emotion-eliciting stimulus had disappeared – that is, during the evaluation phase. While this is entirely consistent with the approach taken elsewhere (Hot et al., 2005; Driscoll et al., 2009; Sheppes and Meiran, 2007; Dan-Glauser and Gross, 2013; Troy et al., 2018), the timing of ER initiation has been shown to modulate the degree of convergence between measures; no changes are observed in skin-conductance responses to negative images when individuals are instructed to regulate their emotions *before* viewing the stimuli, but these physiological responses are increased when ER is recommended during the viewing of the stimuli (Sheppes et al., 2009; Sheppes and Meiran, 2007).

On the other hand, these discrepancies might indicate that subjective ratings reflect processes independent of the physiological affective response; they may capture an individual's evaluation of their implementation of an ER strategy, rather than their actual experience of the resultant affective state (Hot et al., 2005; Wiens, 2005). We interpret the strongest divergence between measures on Frame trials to support this notion. An individual's ER ability is influenced by their self-perceived efficacy (Colombo et al., 2020; Tamir and Mauss, 2011) and beliefs about the controllability of their emotions (Ford and Gross, 2019; De Castella et al., 2013; De Castella et al., 2015). Our sample scored relatively low on the Difficulties in Emotion Regulation Scale, and so they appeared to perceive themselves as fairly effective regulators. Perhaps, then, the frames recommended to them, which they might not have chosen themselves, were evaluated subjectively as inefficacious. Simultaneously, however, these frames may have been sufficiently salient to elicit exogenous shifts of attention away from the images themselves, thereby serving as an implicit form of antecedent-focused ER that reduced the depth of their processing and any resultant physiological response (Gyurak et al., 2011; Steptoe and Vögele, 1986). Indeed, a substantial body of research demonstrates the powerful influence of exogenous cues in re-directing attention (Berger et al., 2005; Chica et al., 2013; Theeuwes, 1991; Bowling et al., 2020) and the processing of emotional content (Brosch et al., 2011), which forms the basis of attention training in the context of affective disorders (MacLeod et al., 2002; Amir et al., 2009; Papageorgiou and Wells, 2000).

4.3. Implications and future directions

The superiority of ER under external guidance has potential implications for the treatment of affective disorders, which focus currently on altering the patient's cognition and behaviours (Aldao et al., 2014; Asnaani et al., 2020), their awareness and acceptance of emotional processes (Ford et al., 2018; Lindsay and Creswell, 2019), or a combination of both (Troy et al., 2018; Fassbinder et al., 2016). However, in light of growing evidence for the beneficial effect of inter-personal intrinsic ER, alternative treatments involving inter-personal dynamics among friends and family might prove more effective in reducing emotion dysregulation and preventing relapse. In particular, further research on pre-generative influences on emotion is needed to assess the efficacy of the regulator's strategy choice for others with maladaptive strategy preferences, such as a chronic use of expressive suppression and rumination, which have been linked to psychopathology (Aldao et al., 2010; Chervonsky and Hunt, 2017). We acknowledge that the mechanisms underlying the apparent superiority of inter- over intra-personal intrinsic ER are yet to be discovered. In our sample, the relative efficacy of inter- over intra-personal ER was not dependent on individuals' self-perceived abilities to regulate their emotions. Indeed, it is still unclear whether the relative benefits of the former are due primarily to the inter-personal dynamic itself (English and Eldesouky, 2020) or if they are moderated by person characteristics known to influence the latter (e.g., Niven et al., 2019, Coan et al., 2006; for a related discussion see Hughes et al., 2020). This requires a much more precise understanding of the conditions under which inter-personal ER is optimised, however, and this, in turn, requires future research to address some of the potential limitations of the present study.

Firstly, the control condition we have employed appears to have been effective in regulating emotions implicitly. To further quantify the beneficial effects of inter-personal intrinsic ER, future studies might compare both intra- and inter-personal ER against a baseline that captures spontaneous emotional reactivity in the absence of any intrinsic regulation. Alternatively, future studies could evaluate the effectiveness of other exogenous distractors as implicit ER strategies, or the manner in which they serve to attenuate emotional reactions. For example, it is likely that the effectiveness of exogenous distractions in down-regulating negative reactions applies only during their presentation, and does not persist into the evaluative period in which the ratings were made (post-presentation). Secondly, future studies are needed to establish whether the superior effectiveness of inter- over intra-personal ER at down-regulating physiological reactions remains when a reversed schedule of recommendations is made – that is, reappraisal for high- and disengagement for low-arousal images. Due to current restrictions imposed by the global pandemic, we were unable to complement our preliminary online data with EDA measurements. It remains to be seen, therefore, whether the convergence in subjective ratings acquired in our laboratory study and those from the preliminary online data holds also for physiological metrics. Future studies under controlled laboratory conditions are needed to determine whether electrodermal responses continue to demonstrate a benefit of inter- over intra-personal ER when the inter-personal recommendations follow a reversed schedule. This would shed more light on the degree to which inter-personal ER relies upon the social dynamic.

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CRediT authorship contribution statement

Nicola Ngombe: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. **Klaus Kessler:** Project administration, Resources, Supervision, Writing – review & editing. **Daniel Joel Shaw:** Project administration, Resources, Supervision, Writing – review & editing.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

Appendix A. Supplementary materials

Supplementary materials to this article can be found online at https://doi.org/10.1016/j.ijpsycho.2022.07.008.

References

Aldao, A., Nolen-Hoeksema, S., Schweizer, S., 2010. Emotion-regulation strategies across psychopathology: a meta-analytic review. Clin. Psychol. Rev. 30, 217–237.
Aldao, A., Jazaieri, H., Goldin, P.R., Gross, J.J., 2014. Adaptive and maladaptive emotion regulation strategies: interactive effects during CBT for social anxiety disorder. J. Anxiety Disord. 28, 382–389.
Amir, N., Beard, C., Taylor, C.T., Klumpp, H., Elias, J., Burns, M., Chen, X., 2009. Attention training in individuals with generalized social phobia: a randomized controlled trial. J. Consult. Clin. Psychol. 77, 961.
Asnaani, A., Tyler, J., McCann, J., Brown, L., Zang, Y., 2020. Anxiety sensitivity and emotion regulation as mechanisms of successful CBT outcome for anxiety-related disorders in a naturalistic treatment setting. J. Affect. Disord. 267, 86–95.
Barlow, D.H., Allen, L.B., Choate, M.L., 2004. Toward a unified treatment for emotional disorders. Behav. Ther. 35, 205–230.
Barrett, L.F., Bliss-Moreau, E., 2009. Affect as a psychological primitive. In: Zanna, M.P. (Ed.), Advances in Experimental Social Psychology, Vol 41.
Barthel, A.L., Hay, A., Doan, S.N., Hofmann, S.G., 2018. Interpersonal emotion regulation: a review of social and developmental components. Behav. Chang. 35, 203–216.
Beaudreau, S.A., O'Hara, R., 2008. Late-life anxiety and cognitive impairment: a review. Am. J. Geriatr. Psychiatr. 16, 790–803.
Benedek, M., Kaernbach, C., 2010. A continuous measure of phasic electrodermal activity. J. Neurosci. Methods 190, 80–91.
Berger, A., Henik, A., Rafal, R., 2005. Competition between endogenous and exogenous orienting of visual attention. J. Exp. Psychol. Gen. 134, 207.
Bernat, E.M., Cadwallader, M., Seo, D., Vizueta, N., Patrick, C.J., 2011. Effects of instructed emotion regulation on valence, arousal, and attentional measures of affective processing. Dev. Neuropsychol. 36, 493–518.
Bonanno, G.A., Burton, C.L., 2013. Regulatory flexibility: an individual differences perspective on coping and emotion regulation. Perspect. Psychol. Sci. 8, 591–612.
Bowling, J.T., Friston, K.J., Hopfinger, J.B., 2020. Top-down versus bottom-up attention differentially modulate frontal–parietal connectivity. Hum. Brain Mapp. 41, 928–942.
Bradley, M.M., Lang, P.J., 1994. Measuring emotion: the self-assessment manikin and the semantic differential. J. Behav. Ther. Exp. Psychiatry 25, 49–59.
Brosch, T., Pourtois, G., Sander, D., Vuilleumier, P., 2011. Additive effects of emotional, endogenous, and exogenous attention: behavioral and electrophysiological evidence. Neuropsychologia 49, 1779–1787.
Brown, C.L., Van Doren, N., Ford, B.Q., Mauss, I.B., Sze, J.W., Levenson, R.W., 2019. Coherence between subjective experience and physiology in emotion: individual differences and implications for well-being. Emotion 20 (5), 818–829. https://doi.org/10.1037/emo0000579.
Butler, E.A., 2017. Emotions are temporal interpersonal systems. Curr. Opin. Psychol. 17, 129–134.
Cacioppo, J.T., Gardner, W.L., 1999. Emotion. Annu. Rev. Psychol. 50, 191–214.
Cacioppo, J.T., Tassinary, L.G., 1990. Inferring psychological significance from physiological signals. Am. Psychol. 45, 16.
Camodeca, M., Nava, E., 2020. The long-term effects of bullying, victimization, and bystander behavior on emotion regulation and its physiological correlates. J. Interpers. Violence 37 (3–4), NP2056–NP2075. https://doi.org/10.1177/0886260520934438.
de Castella, K., Goldin, P., Jazaieri, H., Ziv, M., Dweck, C.S., Gross, J.J., 2013. Beliefs about emotion: links to emotion regulation, well-being, and psychological distress. Basic Appl. Soc. Psychol. 35, 497–505.
de Castella, K., Goldin, P., Jazaieri, H., Heimberg, R.G., Dweck, C.S., Gross, J.J., 2015. Emotion beliefs and cognitive behavioural therapy for social anxiety disorder. Cogn. Behav. Ther. 44, 128–141.
Chervonsky, E., Hunt, C., 2017. Suppression and expression of emotion in social and interpersonal outcomes: a meta-analysis. Emotion 17, 669–683.
Chica, A.B., Bartolomeo, P., Lupiáñez, J., 2013. Two cognitive and neural systems for endogenous and exogenous spatial attention. Behav. Brain Res. 237, 107–123.
Christensen, K.A., van Dyk, I.S., Nelson, S.V., Vasey, M.W., 2020. Using multilevel modeling to characterize interpersonal emotion regulation strategies and psychopathology in female friends. Personal. Individ. Differ. 165, 110156.
Cludius, B., Mennin, D., Ehring, T., 2020. Emotion regulation as a transdiagnostic process. Emotion 20, 37.
Coan, J.A., Schaefer, H.S., Davidson, R.J., 2006. Lending a hand: social regulation of the neural response to threat. Psychol. Sci. 17, 1032–1039.
Colombo, D., Fernández-Álvarez, J., Suso-Ribera, C., Cipresso, P., Valev, H., Leufkens, T., Sas, C., Garcia-Palacios, A., Riva, G., Botella, C., 2020. The need for change: understanding emotion regulation antecedents and consequences using ecological momentary assessment. Emotion 20, 30.
Dan-Glauser, E.S., Gross, J.J., 2013. Emotion regulation and emotion coherence: evidence for strategy-specific effects. Emotion 13, 832.
Demaree, H., Schmeichel, B., Robinson, J., Everhart, D.E., 2004. Behavioural, affective, and physiological effects of negative and positive emotional exaggeration. Cognit. Emot. 18, 1079–1097.

Dixon-Gordon, K.L., Bernecker, S.L., Christensen, K., 2015. Recent innovations in the field of interpersonal emotion regulation. Curr. Opin. Psychol. 3, 36–42.
Driscoll, D., Tranel, D., Anderson, S.W., 2009. The effects of voluntary regulation of positive and negative emotion on psychophysiological responsiveness. Int. J. Psychophysiol. 72, 61–66.
Ekman, P., 1992. An argument for basic emotions. Cognit. Emot. 6, 169–200.
English, T., Eldesouky, L., 2020. We're not alone: understanding the social consequences of intrinsic emotion regulation. Emotion 20, 43.
English, T., Lee, I.A., John, O.P., Gross, J.J., 2017. Emotion regulation strategy selection in daily life: the role of social context and goals. Motiv. Emot. 41, 230–242.
Fassbinder, E., Schweiger, U., Martius, D., Brand-de Wilde, O., Arntz, A., 2016. Emotion regulation in schema therapy and dialectical behavior therapy. Front. Psychol. 7, 1373.
Faul, F., Erdfelder, E., Lang, A.-G., Buchner, A., 2007. G* power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav. Res. Methods 39, 175–191.
Ford, B.Q., Gross, J.J., 2019. Why beliefs about emotion matter: an emotion-regulation perspective. Curr. Dir. Psychol. Sci. 28, 74–81.
Ford, B.Q., Lam, P., John, O.P., Mauss, I.B., 2018. The psychological health benefits of accepting negative emotions and thoughts: laboratory, diary, and longitudinal evidence. J. Pers. Soc. Psychol. 115, 1075.
Goldin, P.R., McRae, K., Ramel, W., Gross, J.J., 2008. The neural bases of emotion regulation: reappraisal and suppression of negative emotion. Biol. Psychiatry 63, 577–586.
Gratz, K.L., Roemer, L., 2004. Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. J. Psychopathol. Behav. Assess. 26, 41–54.
Gross, J.J., 1998. Antecedent- and response-focused emotion regulation: divergent consequences for experience, expression, and physiology. J. Pers. Soc. Psychol. 74, 224–237.
Gross, J.J., 1998. The emerging field of emotion regulation: an integrative review. Rev. Gen. Psychol. 2, 271–299.
Gross, J.J., 2001. Emotion regulation in adulthood: timing is everything. Curr. Dir. Psychol. Sci. 10, 214–219.
Gross, J.J., 2015. Emotion regulation: current status and future prospects. Psychol. Inq. 26, 1–26.
Gross, J.J., Jazaieri, H., 2014. Emotion, emotion regulation, and psychopathology: an affective science perspective. Clin. Psychol. Sci. 2, 387–401.
Gross, J.J., Levenson, R.W., 1993. Emotional suppression: physiology, self-report, and expressive behavior. J. Pers. Soc. Psychol. 64, 970.
Gyurak, A., Gross, J.J., Etkin, A., 2011. Explicit and implicit emotion regulation: a dual-process framework. Cognit. Emot. 25, 400–412.
Hajcak, G., Macnamara, A., Olvet, D.M., 2010. Event-related potentials, emotion, and emotion regulation: an integrative review. Dev. Neuropsychol. 35, 129–155.
Hallam, G.P., Webb, T.L., Sheeran, P., Miles, E., Niven, K., Wilkinson, I.D., Hunter, M.D., Woodruff, P.W.R., Totterdell, P., Farrow, T.F.D., 2014. The neural correlates of regulating another person's emotions: an exploratory fMRI study. Front. Hum. Neurosci. 8.
Hallion, L.S., Steinman, S.A., Tolin, D.F., Diefenbach, G.J., 2018. Psychometric properties of the difficulties in emotion regulation scale (DERS) and its short forms in adults with emotional disorders. Front. Psychol. 9, 539.
Hot, P., Leconte, P., Sequeira, H., 2005. Diurnal autonomic variations and emotional reactivity. Biol. Psychol. 69, 261–270.
Hubert, W., De Jong-Meyer, R., 1990. Psychophysiological response patterns to positive and negative film stimuli. Biol. Psychol. 31, 73–93.
Hughes, D.J., Kratsiotis, I.K., Niven, K., Holman, D., 2020. Personality traits and emotion regulation: a targeted review and recommendations. Emotion 20, 63.
Jackson, D.C., Malmstadt, J.R., Larson, C.L., Davidson, R.J., 2000. Suppression and enhancement of emotional responses to unpleasant pictures. Psychophysiology 37, 515–522.
Kim, S.H., Hamann, S., 2007. Neural correlates of positive and negative emotion regulation. J. Cogn. Neurosci. 19, 776–798.
Lang, P.J., Bradley, M.M., Cuthbert, B.N., 2008. International Affective Picture System (IAPS): Affective Ratings of Pictures and Instruction Manual. University of Florida, Gainesville. Tech Rep A-8.
Lepore, S.J., Allen, K., Evans, G.W., 1993. Social support lowers cardiovascular reactivity to an acute stressor. Psychosom. Med. 55, 518–524.
Levy-Gigi, E., Shamay-Tsoory, S.G., 2017. Help me if you can: evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress. J. Behav. Ther. Exp. Psychiatry 55, 33–40.
Levy-Gigi, E., Bonanno, G.A., Shapiro, A.R., Richter-Levin, G., Keri, S., Sheppes, G., 2016. Emotion regulatory flexibility sheds light on the elusive relationship between repeated traumatic exposure and posttraumatic stress disorder symptoms. Clin. Psychol. Sci. 4 (1), 28–39. https://doi.org/10.1177/2167702615577783.
Lindsay, E.K., Creswell, J.D., 2019. Mindfulness, acceptance, and emotion regulation: perspectives from monitor and acceptance theory (MAT). Curr. Opin. Psychol. 28, 120–125.
Lindsey, E.W., 2020. Relationship context and emotion regulation across the life span. Emotion 20, 59.
Lougheed, J.P., Koval, P., Hollenstein, T., 2016. Sharing the burden: the interpersonal regulation of emotional arousal in mother– daughter dyads. Emotion 16, 83.
Macleod, C., Rutherford, E., Campbell, L., Ebsworthy, G., Holker, L., 2002. Selective attention and emotional vulnerability: assessing the causal basis of their association through the experimental manipulation of attentional bias. J. Abnorm. Psychol. 111, 107.
Mathworks, M., 2017. MATLAB and Statistics Toolbox Release. The MathWorks. Inc, Natick, MA.
Mauss, I.B., Levenson, R.W., McCarter, L., Wilhelm, F.H., Gross, J.J., 2005. The tie that binds? Coherence among emotion experience, behavior, and physiology. Emotion 5, 175.
McRae, K., Gross, J.J., 2020. Emotion regulation. Emotion 20, 1.
Morawetz, C., Berboth, S., Bode, S., 2021. With a little help from my friends: the effect of social proximity on emotion regulation-related brain activity. NeuroImage 230 (1), 1–12. https://doi.org/10.1016/j.neuroimage.2021.117817, 117817.
Netzer, L., van Kleef, G.A., Tamir, M., 2015. Interpersonal instrumental emotion regulation. J. Exp. Soc. Psychol. 58, 124–135.
Niven, K., Troth, A.C., Holman, D., 2019. Do the effects of interpersonal emotion regulation depend on people's underlying motives? J. Occup. Organ. Psychol. 92, 1020–1026.
Nozaki, Y., Mikolajczak, M., 2020. Extrinsic emotion regulation. Emotion 20, 10.
Ochsner, K.N., Gross, J.J., 2005. The cognitive control of emotion. Trends Cogn. Sci. 9, 242–249.
Pacella, D., López-Pérez, B., 2018. Assessing children's interpersonal emotion regulation with virtual agents: the serious game emodiscovery. Comput. Educ. 123, 1–12.
Papageorgiou, C., Wells, A., 2000. Treatment of recurrent major depression with attention training. Cogn. Behav. Pract. 7, 407–413.
Pauw, L.S., Sauter, D.A., van Kleef, G.A., Fischer, A.H., 2019. Stop crying! The impact of situational demands on interpersonal emotion regulation. Cognit. Emot. 33, 1587–1598.
Peirce, J., Gray, J.R., Simpson, S., Macaskill, M., Höchenberger, R., Sogo, H., Kastman, E., Lindeløv, J.K., 2019. PsychoPy2: experiments in behavior made easy. Behav. Res. Methods 51, 195–203.
Raio, C.M., Orederu, T.A., Palazzolo, L., Shurick, A.A., Phelps, E.A., 2013. Cognitive emotion regulation fails the stress test. Proc. Natl. Acad. Sci. 110, 15139–15144.
Ray, R.D., McRae, K., Ochsner, K.N., Gross, J.J., 2010. Cognitive reappraisal of negative affect: converging evidence from EMG and self-report. Emotion 10, 587.
Robinson, J.L., Demaree, H.A., 2009. Experiencing and regulating sadness: physiological and cognitive effects. Brain Cogn. 70, 13–20.
Rosenberg, E.L., 1997. Emotions as unified responses. In: Paul Ekman Erika L. Rosenberg, p. 86.
Rosenberg, E.L., Ekman, P., 1994. Coherence between expressive and experiential systems in emotion. Cognit. Emot. 8, 201–229.
Scheibe, S., Sheppes, G., Staudinger, U.M., 2015. Distract or Reappraise? Age-related differences in emotion-regulation choice. Emotion 15, 677–681.
Shafir, R., Sheppes, G., 2020. How anticipatory information shapes subsequent emotion regulation. Emotion 20, 68.
Shafir, R., Schwartz, N., Blechert, J., Sheppes, G., 2015. Emotional intensity influences pre-implementation and implementation of distraction and reappraisal. Soc. Cogn. Affect. Neurosci. 10, 1329–1337.
Sheppes, G., Meiran, N., 2007. Better late than never? On the dynamics of online regulation of sadness using distraction and cognitive reappraisal. Personal. Soc. Psychol. Bull. 33, 1518–1532.
Sheppes, G., Catran, E., Meiran, N., 2009. Reappraisal (but not distraction) is going to make you sweat: physiological evidence for self-control effort. Int. J. Psychophysiol. 71, 91–96.
Sheppes, G., Scheibe, S., Suri, G., Gross, J.J., 2011. Emotion-regulation choice. Psychol. Sci. 22, 1391–1396.
Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., Gross, J.J., 2014. Emotion regulation choice: a conceptual framework and supporting evidence. J. Exp. Psychol. Gen. 143, 163–181.
Sheppes, G., Suri, G., Gross, J.J., 2015. Emotion regulation and psychopathology. Annu. Rev. Clin. Psychol. 11 (11), 379–405.
Steptoe, A., Vögele, C., 1986. Are stress responses influenced by cognitive appraisal? An experimental comparison of coping strategies. Br. J. Psychol. 77, 243–255.
Swart, M., Kortekaas, R., Aleman, A., 2009. Dealing with feelings: characterization of trait alexithymia on emotion regulation strategies and cognitive-emotional processing. PloS one 4.
Sze, J.A., Gyurak, A., Yuan, J.W., Levenson, R.W., 2010. Coherence between emotional experience and physiology: does body awareness training have an impact? Emotion 10, 803.
Tamir, M., Mauss, I.B., 2011. Social cognitive factors in emotion regulation: implications for well-being. In: Emotion Regulation and Well-being. Springer.
Tamir, M., Vishkin, A., Gutentag, T., 2020. Emotion regulation is motivated. Emotion 20, 115.

Theeuwes, J., 1991. Exogenous and endogenous control of attention: the effect of visual onsets and offsets. Percept. Psychophys. 49, 83–90.
Troy, A.S., Shallcross, A.J., Brunner, A., Friedman, R., Jones, M.C., 2018. Cognitive reappraisal and acceptance: effects on emotion, physiology, and perceived cognitive costs. Emotion 18, 58.
Uchino, B.N., Uno, D., Holt-Lunstad, J., 1999. Social support, physiological processes, and health. Curr. Dir. Psychol. Sci. 8, 145–148.
Urry, H.L., 2009. Using reappraisal to regulate unpleasant emotional episodes: goals and timing matter. Emotion 9, 782.
Urry, H.L., 2010. Seeing, thinking, and feeling: emotion-regulating effects of gaze-directed cognitive reappraisal. Emotion 10, 125.
Wiens, S., 2005. Interoception in emotional experience. Curr. Opin. Neurol. 18, 442–447.
Xie, X., Bratec, S.M., Schmid, G., Meng, C., Doll, A., Wohlschlaeger, A., Finke, K., Foestl, H., Zimmer, C., Pekrun, R., Schilbach, L., Riedl, V., Sorg, C., 2016. How do you make me feel better? Social cognitive emotion regulation and the default mode network. NeuroImage 134, 270–280.
Zaki, J., 2020. Integrating empathy and interpersonal emotion regulation. Annu. Rev. Psychol. 71, 517–540.
Zaki, J., Williams, W.C., 2013. Interpersonal emotion regulation. Emotion 13, 803–810.